

Flow: Oil-water separation

(20 marks)

The dimensions of a horizontal channel in an oil-water separator are 2.50 m (length), 1.00 m (width) and 1.20 cm (height). Through the channel water, containing a very low concentration of small oil droplets, is flowing. The average velocity of the oil-water mixture is 1.86 cm/s. Specific masses of oil and water are, respectively, 885 and 1000 kg/m³. The dynamic viscosity of water is 0.00095 Pa.s, and the acceleration of gravity is 9.80 m/s².

Questions:

- (1) Calculate the critical oil droplet diameter (in micrometers).
- (2) Demonstrate that the flow in the separator channel is laminar.
- (3) For which oil droplet diameter is valid that the droplet Reynolds number is 1?

Heat transfer: Pipe insulation

(20 marks)

A cast iron steam pipe of 0.11 m O.D. and 0.10 m I.D. carries steam at 200°C. It is to be insulated with a 0.025 m thick of insulating material of $k_m=0.035$ W/mK. the ambient temperature is 0°C and the outer and inner heat transfer coefficients are 75 and 225 W/m²K, respectively.

Question:

- (1) Show that heat flux through the wall of the pipe is less when the insulation is placed on the inner surface than when it is placed on the outer surface.
- (2) What thickness of insulation, when placed on the outer surface, gives the same heat flux through the wall as a 0.025-m thickness placed on the inner wall?

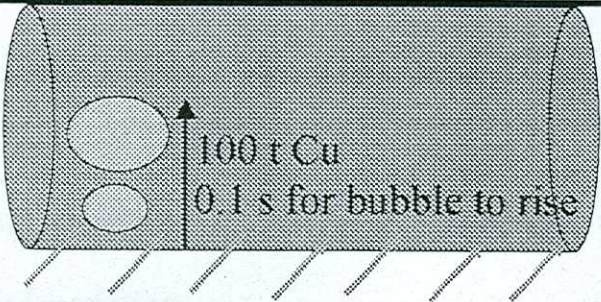
Mass Transfer: Deoxidation of liquid copper

(20 marks)

Copper is deoxidized by bubbling methane gas through it. If it can be assumed that it takes a bubble 0.1 seconds to reach the top of the copper bath and that $50 \text{ Nm}^3/\text{h}$ of gas is used, how long will it take to reduce the oxygen concentration in 100t copper by 90%? All the required data are given below.

Please give reasons for all assumptions you make in your calculations.

Data



$(50 \text{ Nm}^3 \text{ CH}_4 / \text{h}) : \text{CH}_4 + 4(\text{O})_{\text{Cu}} = \text{CO}_2 + 2\text{H}_2\text{O}$

Area = $4.84(\text{V})^{2/3}$

$k = 0.0824 \text{ m/s}$
1 atm / 1 cm^3

0.2 wt% O in Cu
 8000 kg/m^3
1500K
 $k = 0.0004 \text{ m/s}$ for O